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T Plant Leaves for the Production of Oxygen in a Closed System

(NASA Contract NASr-129)

Final Report

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SUMMARY OF WORK UNDER CONTRACT NASr-12[redacted]

We have screened numerous species of higher plants for use in a closed ecological system. Our primary criteria for selection were maximum O_2 production rate from a unit of leaf area, ease of maintaining and reproducing the plants, their persistence in continuous illumination and ease of lighting many leaves packed into a small volume. A final consideration was the ease with which an edible product could be obtained from the plant.

Many species were eliminated because they yield little outdoors. Others were rejected because they absorbed CO_2 slowly. Among these were many trees and such common crops as orchard grass, red clover and tobacco.

Further experiments were conducted with the three most promising species - maize, sugar cane, and sunflower. Our choice for initial tests in our pilot system was sugar cane. It has the highest O_2 production per unit leaf of any plant we tested, can be grown as a perennial and can be quickly started from the root system. Thus, new plants need not start from seed. The growth habit of cane allows many leaves to be confined in a small volume. Further, cane appears to better withstand continuous illumination from fluorescent lamps with less harmful destruction of chlorophyll. Finally, much of the CO_2 that is fixed can easily be extracted as digestable carbohydrates.

The optimum conditions for O_2 production by cane have been determined. We found that high rates of CO_2 absorption could be achieved by lighting both surfaces of leaves with lower illumination than required for maximum production when light is from one direction only. A temperature of 30 C and 0.1 per cent CO_2 in the atmosphere were ideal; these conditions would not harm men enclosed in the sytem.

The closed system that employs sugar cane to produce O_2 and consume CO_2 can be simple and weigh little. Since leaves have membranes which confine the active cells, and since no toxic substances are released into the atmosphere by cane, the system does not need filters or complicated membrane pumps such as would be necessary for single-celled aquatic plants. A source of illumination, a simple fan to circulate the air through the quarters of the men and back to the plant chamber, and a simple condenser to remove water from the air and return it to the roots are the only accessory equipment needed. Further, the plants can be grown with little water about their roots. Thus, the total weight and complexity of the system can be low. We have constructed a closed system designed to support two men. A single test was completed with this chamber using sugar cane as a test plant. In that test, the two foot square area produced only one-tenth the O_2 needed to support a man. The major difficulty was found to be chlorophyll bleaching in leaves nearest the lights. Thus, these leaves were not producing O_2 and, in turn, shaded other leaves cutting their production rate. However, of great promise was the fact that an extremely large area of leaves (estimated 400 ft^2) was maintained in the chamber for three months. Thus, if only half the maximum rate of photosynthesis could be maintained, the chamber could support two men.

Three areas should be explored in future research with maize, sugar cane and sunflower: 1) Lights should be arranged so shading is minimal. 2) Spectral composition of light should be altered to reduce chlorophyll destruction in continuous light. 3) Short dark periods should be tested. This last measure would require a backup system in any operational program to provide O_2 during the time one system is inoperative due to darkness.

All experiments under NASr-129 have been reported in detail in the four quarterly reports submitted. One manuscript entitled "Optimum Lighting of Leaves" by Dale N. Moss has been submitted to and accepted by <u>Crop Science</u> for publication in that journal. Twenty-five pre-publication copies of the manuscript were submitted to Grants and Research Contracts, NASA as required under terms of contract NASr-129. In addition, the fourth quarterly status report contains a fairly detailed summary of the work done under NASr-129.